

What is claimed is:

1. Apparatus for transmitting a sub-rate data stream over a communication network that uses a selected network protocol, wherein the sub-rate data stream has an associated sub-rate protocol, the apparatus comprising:

a rate adapter coupled to receive the sub-rate data stream and operable to adapt a rate characteristic associated with the sub-rate protocol to a rate characteristic associated with the selected network protocol to generate a rate-adapted data stream from the sub-rate data stream; and

a payload framer coupled to receive the rate-adapted data stream and operable to frame the rate-adapted data stream into a payload for transmission over the communication network using the selected network protocol.

2. The apparatus of claim 1, further comprising a de-serializer having logic to receive a serial version of the sub-rate data stream and form the sub-rate data stream.

3. The apparatus of claim 2, wherein the de-serializer includes a clock recovery circuit that recovers a sub-rate clock associated with the sub-rate data stream, and wherein the sub-rate clock is coupled to the rate adapter.

4. The apparatus of claim 2, wherein the de-serializer includes compression logic to compress the serial version of the sub-rate data stream to form the sub-rate data stream.

5. The apparatus of claim 1, wherein the rate adapter includes a first-in-first-out (FIFO) memory to provide storage for the sub-rate data stream.

6. The apparatus of claim 1, wherein the rate adapter includes logic to determine a stuffing opportunity that indicates an amount of stuffing data of the rate-adapted data stream to be framed in the payload.

7. The apparatus of claim 6, wherein the rate adapter generates a stuffing opportunity indicator that is coupled to the payload framer.

8. The apparatus of claim 7, wherein the payload framer includes logic to receive the stuffing opportunity indicator and frame the stuffing data into the payload based on the stuffing opportunity indicator.

9. The apparatus of claim 1, further comprising a network framer coupled to the payload framer and having logic to receive the payload, frame the payload into a network frame, and transmit the network frame over the communication network using the selected network protocol.

10. Apparatus for receiving a sub-rate data stream over a communication network that uses a selected network protocol, wherein the sub-rate data stream has an associated sub-rate protocol, the apparatus comprising:

a payload de-framer coupled to receive a payload transmitted over the communication network using the selected network protocol and to de-frame the payload into a rate-adapted data stream that is representative of the sub-rate data stream; and

a rate adapter coupled to receive the rate-adapted data stream and operable to adapt a rate characteristic associated with the selected network protocol to a rate characteristic associated with the sub-rate protocol to generate the sub-rate data stream from the rate-adapted data stream.

11. The apparatus of claim 10, further comprising a serializer coupled to the rate adapter and having logic to receive the sub-rate data and produce a serial version of the sub-rate data stream.

12. The apparatus of claim 11, wherein the serializer includes decompression logic to decompress the sub-rate data stream to form the serial version of the sub-rate data stream.

13. The apparatus of claim 10, wherein the rate adapter further comprises:  
logic to determine a stuffing opportunity that indicates an amount of stuffing data included in the rate-adapted data stream; and  
logic to include the stuffing data in the sub-rate data stream.

14. The apparatus of claim 10, further comprising clock logic that provides a local clock signal that is coupled to the rate adapter, wherein the local clock signal is associated with the sub-rate protocol.

15 15. The apparatus of claim 10, wherein the payload de-framer includes frame acquisition logic to detect a frame marker in the payload.

16. The apparatus of claim 10, further comprising a network de-framer coupled to the payload de-framer and having logic to receive a network frame transmitted over the communication network using the selected network protocol and de-frame the payload from the network frame.

10 17. System for transporting a sub-rate data stream over a communication network that uses a selected network protocol, wherein the communication network includes a plurality of interconnected network elements, and wherein the sub-rate data stream has an associated sub-rate protocol, the system comprising:

15 a transmit rate adapter located at a source network element that is coupled to receive the sub-rate data stream and operable to adapt a rate characteristic associated with the sub-rate protocol to a rate characteristic associated with the selected network protocol to generate a rate-adapted data stream from the sub-rate data stream;

20 a payload framer located at the source network element that is coupled to receive the rate-adapted data stream and operable to frame the rate-adapted data stream into a payload that is transmitted over the communication network using the selected network protocol;

25 a payload de-framer located at a destination network element that is coupled to receive the payload transmitted over the communication network using the selected network protocol and to de-frame the payload into the rate-adapted data stream that is representative of the sub-rate data stream; and

a receive rate adapter located at the destination network element that is coupled to receive the rate-adapted data stream and operable to adapt a rate characteristic associated with the selected network protocol to a rate characteristic associated with the sub-rate protocol to generate the sub-rate data stream from the rate-adapted data stream.

18. The system of claim 17, further comprising a de-serializer located at the source network element and having logic to receive a serial version of the sub-rate data stream and form the sub-rate data stream.

19. The system of claim 18, wherein the de-serializer includes a clock recovery circuit that recovers a sub-rate clock associated with the sub-rate data stream, and wherein the sub-rate clock is coupled to the transmit rate adapter.

20. The system of claim 18, wherein the de-serializer includes compression logic to compress the serial version of the sub-rate data stream to form the sub-rate data stream.

21. The system of claim 17, wherein the transmit rate adapter includes a first-in-first-out (FIFO) memory to provide storage for the sub-rate data stream.

22. The system of claim 17, wherein the transmit rate adapter includes logic to determine a stuffing opportunity that indicates an amount of stuffing data of the rate-adapted data stream to be framed in the payload.

23. The system of claim 22, wherein the transmit rate adapter includes logic that outputs a stuffing opportunity indicator to the payload framer.

24. The system of claim 23, wherein the payload framer includes logic to receive the stuffing opportunity indicator and frame the stuffing data into the payload based on the stuffing opportunity indicator.

25. The system of claim 17, further comprising a network framer coupled to the payload framer and having logic to receive the payload, frame the payload into a network frame, and transmit the network frame over the communication network using the selected network protocol.

26. The system of claim 17, further comprising a serializer located at the destination network element and coupled to the receive rate adapter and having logic to receive the sub-rate data stream and produce a serial version of the sub-rate data stream.

27. The system of claim 26, wherein the serializer includes decompression logic to decompress the sub-rate data stream to form the serial version of the sub-rate data stream.

28. The system of claim 17, wherein the receive rate adapter further  
5 comprises:  
logic to determine a stuffing opportunity that indicates an amount of stuffing data included in the rate-adapted data stream; and  
logic to include the stuffing data in the sub-rate data stream.

29. The system of claim 17, wherein the receive rate adapter further comprises  
10 clock logic that provides a local clock signal that is coupled to the rate adapter, wherein the local clock signal is associated with the sub-rate protocol.

30. The system of claim 17, wherein the payload de-framer includes frame acquisition logic to detect a frame marker in the payload.

31. The system of claim 17, further comprising a network de-framer coupled  
15 to the payload de-framer and having logic to receive a network frame transmitted over the communication network using the selected network protocol and de-frame the payload from the network frame.

32. Method for transmitting a sub-rate data stream over a communication network that uses a selected network protocol, wherein the sub-rate data stream has an  
20 associated sub-rate protocol, the method comprising steps of:

adapting a rate characteristic associated with the sub-rate protocol to a rate characteristic associated with the selected network protocol to generate a rate-adapted data stream from the sub-rate data stream; and

framing the rate-adapted data stream into a payload for transmission over the  
25 communication network using the selected network protocol.

33. The method of claim 32, further comprising a step of de-serializing a serial version of the sub-rate data stream to form the sub-rate data stream.

34. The method of claim 33, wherein the step of de-serializing includes a step of recovering a sub-rate clock associated with the sub-rate data stream.

35. The method of claim 33, wherein the step of de-serializing includes a step of compressing the serial version of the sub-rate data stream to form the sub-rate data stream.

36. The method of claim 32, wherein the step of adapting includes a step of storing the sub-rate data stream in a first-in-first-out (FIFO) memory.

37. The method of claim 32, wherein the step of adapting includes a step of determining a stuffing opportunity that indicates an amount of stuffing data associated with the rate-adapted data stream to be framed in the payload.

38. The method of claim 37, further comprising a step of generating a stuffing opportunity indicator associated with the stuffing data.

39. The method of claim 38, wherein the step of framing includes a step of framing the stuffing data into the payload based on the stuffing opportunity indicator.

40. The method of claim 32, further comprising steps of:  
framing the payload into a network frame; and  
transmitting the network frame over the communication network using the selected network protocol.

41. Method for receiving a sub-rate data stream over a communication network that uses a selected network protocol, wherein the sub-rate data stream has an associated sub-rate protocol, the method comprising steps of:

de-framing a payload transmitted over the communication network using the selected network protocol into a rate-adapted data stream that is representative of the sub-rate data stream; and  
adapting a rate characteristic associated with the selected network protocol to a rate characteristic associated with the sub-rate protocol to generate the sub-rate data stream from the rate-adapted data stream.

42. The method of claim 41, further comprising a step of serializing the sub-rate data stream to produce a serial version of the sub-rate data stream.

43. The method of claim 42, wherein the step of serializing further comprises a step of decompressing the sub-rate data stream to form the serial version of the sub-rate data stream.

44. The method of claim 41, wherein the step of adapting includes steps of:  
determining a stuffing opportunity that indicates an amount of stuffing data included in the rate-adapted data stream; and  
including the stuffing data in the sub-rate data stream.

45. The method of claim 41, wherein the step of adapting includes a step of generating a local clock signal that is associated with the selected network protocol.

46. The method of claim 41, wherein the step of de-framing includes a step of detecting a frame marker in the payload.

47. The method of claim 41, further comprising steps of:  
receiving a network frame over the communication network using the selected network protocol; and  
de-framing the payload from the network frame.

48. Method for transporting a sub-rate data stream over a communication network that uses a selected network protocol, wherein the sub-rate data stream has an associated sub-rate protocol, the method comprising steps of:

adapting a receive-rate characteristic associated with the sub-rate protocol to a transmit-rate characteristic associated with the selected network protocol to generate a rate-adapted data stream from the sub-rate data stream; and

framing the rate-adapted data stream into a payload that is transmitted over the communication network using the selected network protocol.

de-framing the payload transmitted over the communication network using the selected network protocol into the rate-adapted data stream that is representative of the

sub-rate data stream; and

adapting the transmit-rate characteristic associated with the selected network protocol to the receive-rate characteristic associated with the sub-rate protocol to generate the sub-rate data stream.

5           49.     The method of claim 48, further comprising a step of de-serializing a serial version of the sub-rate data stream to form the sub-rate data stream.

50.     The method of claim 49, wherein the step of de-serializing includes a step of recovering a sub-rate clock associated with the sub-rate data stream.

10           51.     The method of claim 49, wherein the step of de-serializing includes a step of compressing the serial version of the sub-rate data stream to form the sub-rate data stream.

52.     The method of claim 48, wherein the step of adapting the receive-rate characteristic includes a step of storing the sub-rate data stream in a first-in-first-out (FIFO) memory.

15           53.     The method of claim 48, wherein the step of adapting the receive-rate characteristic includes a step of determining a stuffing opportunity that indicates an amount of stuffing data associated with the rate-adapted data stream to be framed in the payload.

20           54.     The method of claim 53, further comprising a step of generating a stuffing opportunity indicator associated with the stuffing data.

55.     The method of claim 54, wherein the step of framing includes a step of framing the stuffing data into the payload based on the stuffing opportunity indicator.

56.     The method of claim 48, wherein the step of framing the rate-adapted data stream further comprising steps of:

25           framing the payload into a network frame; and

transmitting the network frame over the communication network using the selected network protocol.



57. The method of claim 48, further comprising a step of serializing the sub-rate data stream to produce a serial version of the sub-rate data stream.

58. The method of claim 57, wherein the step of serializing further comprises a step of decompressing the sub-rate data stream to form the serial version of the sub-rate data stream.

59. The method of claim 48, wherein the step of adapting the transmit-rate characteristic includes steps of:

determining a stuffing opportunity that indicates an amount of stuffing data included in the rate-adapted data stream; and  
including the stuffing data in the sub-rate data stream.

60. The method of claim 59, wherein the step of adapting the transmit-rate characteristic includes a step of generating a local clock signal that is associated with the selected network protocol.

61. The method of claim 48, wherein the step of de-framing includes a step of detecting a frame marker in the payload.

62. The method of claim 48, further comprising steps of:  
receiving a network frame over the communication network using the selected network protocol; and  
de-framing the payload from the network frame.

63. A network element coupled to a communication network to transmit a sub-rate data stream over the communication network using a selected network protocol, wherein the communication network comprises a plurality of interconnected network elements, and wherein the sub-rate data stream has an associated sub-rate protocol, the network element comprising:

a rate adapter coupled to receive the sub-rate data stream and operable to adapt a rate characteristic associated with the sub-rate protocol to a rate characteristic associated with the selected network protocol to generate a rate-adapted data stream;

a payload framer coupled to receive the rate-adapted data stream and operable to frame the rate-adapted data stream into a payload for transmission over the communication network using the selected network protocol; and

stuffing logic coupled to the rate adapter and operable to determine a stuffing  
5 indicator that indicates an amount of the rate-adapted data stream to be framed in the payload.

64. A network element coupled to a communication network to receive a sub-rate data stream transmitted over the communication network using a selected network protocol, wherein the communication network comprises a plurality of interconnected  
10 network elements, and wherein the sub-rate data stream has an associated sub-rate protocol, the network element comprising:

a payload de-framer coupled to receive a payload transmitted over the communication network using the selected network protocol and to de-frame the payload into a rate-adapted data stream that is representative of the sub-rate data stream; and

15 a rate adapter coupled to receive the rate-adapted data stream and operable to adapt a rate characteristic associated with the selected network protocol to a rate characteristic associated with the sub-rate protocol to generate the sub-rate data stream from the rate-adapted data stream and

stuffing logic coupled to the rate adapter and operable to determine a stuffing  
20 indicator that indicates an amount of data in the rate-adapted data stream to be included in the sub-rate data stream.

65. A network element for switching a sub-rate data stream over a communication network that uses a selected network protocol, wherein the communication network includes a plurality of interconnected network elements, and  
25 wherein the sub-rate data stream has an associated sub-rate protocol, the network element comprising:

a payload de-framer that is coupled to receive a first payload transmitted over the communication network using the selected network protocol and to de-frame the first payload into a first rate-adapted data stream that is representative of the sub-rate data  
30 stream;

a receive rate adapter that is coupled to receive the first rate-adapted data stream and is operable to adapt a rate characteristic associated with the selected network protocol to a rate characteristic associated with the sub-rate protocol to generate the sub-rate data stream from the first rate-adapted data stream;

5 a signal path coupled to the receive rate adapter;

a transmit rate adapter that is coupled to the signal path to receive the sub-rate data stream and is operable to adapt a rate characteristic associated with the sub-rate protocol to a rate characteristic associated with the selected network protocol to generate a second rate-adapted data stream from the sub-rate data stream;

10 a payload framer located at the source network element that is coupled to receive the second rate-adapted data stream and is operable to frame the second rate-adapted data stream into a second payload that is transmitted over the communication network using the selected network protocol.

66. The network element of claim 65, wherein the sub-rate data stream is a  
15 first sub-rate data stream, and wherein the transmit rate adapter further comprises:

logic to receive a second sub-rate data stream having a second sub-rate protocol, and wherein the transmit rate adapter is operable to adapt a rate characteristic associated with the second sub-rate protocol to a rate characteristic associated with the selected network protocol to generate a third rate-adapted data stream from the second sub-rate  
20 data stream.

67. The network element of claim 66, wherein the payload framer includes logic to receive the third rate-adapted data stream, and wherein the payload framer is operable to frame the second rate-adapted data stream and the third rate-adapted stream into a third payload that is transmitted over the communication network using the  
25 selected network protocol.